Factors Affecting Curly Top Damage to Sugarbeets and Beans in Southern Idaho, 1919-77

U.S. Department of Agriculture
Science and Education Administration
Agricultural Reviews and Manuals • ARM-W-8/July 1979

A free copy of this publication is available from the Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341.

Science and Education Administration, Agricultural Reviews and Manuals, Western Series, No. 8, July 1979

Published by Agricultural Research (Western Region), Science and Education Administration, U.S. Department of Agriculture, Oakland, Calif. 94612

ABSTRACT

Curly top, a virus disease transmitted only by the beet leafhopper, was a serious threat to the sugarbeet industry in south-central Idaho from 1919 through 1941 and to dry edible and snap bean production from 1924 through 1957. The frequency and severity of damage are charted from 1919 through 1977. The development of plant varieties resistant to curly top is attributed as the major factor in lessening damage to sugarbeets since 1942; the development of plant resistance in beans proceeded at a slower rate, but has also become a major factor in lessening damage. Other possible factors discussed are: (1) size of overwintering beet leafhopper populations, (2) early spring migration of beet leafhoppers, (3) insecticidal control in desert areas, (4) increased general use of pesticides, (5) rangeland improvement by reseeding, and (6) increased size of the cultivated area. The recent increase in the use of beet varieties less resistant to curly top poses a new problem to that industry.

KEYWORDS: Sugarbeets, beans, curly top virus, plant resistance to disease, beet leafhopper, *Beta vulgaris*, *Phaseolus vulgaris*, *Circulifer tenellus*.

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FACTORS AFFECTING CURLY TOP DAMAGE TO SUGARBEETS AND BEANS IN SOUTHERN IDAHO, 1919-77

By C. C. Blickenstaff and Del Traveller[1]

INTRODUCTION

The sugarbeet industry in Idaho began with the establishment of sugarbeet processing factories following the development of irrigation projects. The first factories began operation in eastern Idaho at Idaho Falls in 1903, and at Blackfoot and Sugar City in 1904. In south-central Idaho, factories opened at Burley in 1912, at Twin Falls in 1916, and at Paul (Rupert) in 1917. In western Idaho, a factory opened at Nampa in 1906 but operated only until 1910 (*3*).[2] Considerably later, factories began operation at Nyssa in eastern Oregon in 1938, and at Nampa in 1942 (*4*).

In the irrigated portions of south-central Idaho, the production of beans, *Phaseolus vulgaris* (L.), began in the early 1900's (*43*). The area soon became, and still is, one of the leading dry bean producing areas of the State and is also the leading producer of seed beans in the United States. Bean acreage in south-central Idaho has been more or less constant since about 1940 and has comprised from 75 percent to 94 percent of the State's bean acreage (*6*).

Curly top (CT), a virus disease transmitted only by the beet leafhopper (BLH), *Circulifer tenellus* (Baker), became a serious threat to the production of sugarbeets, *Beta vulgaris* (L.), in southern Idaho in 1919 (*8*), and to beans in 1924 (*7*).

Murphy (*38*) credited the development of CT resistant beet varieties with stabilizing the production of beets. We have added to his records and also describe the development of CT resistant varieties of beans.

We also present and discuss other factors affecting, or possibly affecting, CT incidence and damage to beets and beans including: BLH abundance and viruliferousness, time of BLH movement in the spring, use of insecticides for control, rangeland improvement to replace weed hosts of the BLH, and reduction of desertland because of increased acreage brought into cultivation.

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[2]Italic numbers in parentheses refer to Literature Cited, p. 11.

Available records on beet yield, percentage of beet acreage abandoned, BLH abundance, percentage of viruliferous BLH, and percentage of virus-infected beets and beans are summarized for 1912-77 in table 1.[3] The sources of data for table 1 are given in Appendix I.

YEARS OF SERIOUS DAMAGE

Lange (*33*) listed for Idaho the years of "great beet leafhopper abundance or serious curly top damage" through 1969. The source(s) of his information is not given, but he apparently included damage to beans as a criterion. He did not list 1928, however, when beet yields were greatly reduced (*2*, *25*) or 1949 and 1957 when severe damage to beans occurred. Also, he did not list 1954 or 1966 when overwintering BLH's were most abundant (table 1).

Records of damage to beans, prior to 1935, are probably incomplete. The first report was by Carsner (*7*), and Hungerford (*28*) reported severe damage in 1934. Detailed survey records by USDA personnel are available from 1935 through 1958, and scattered descriptive references from 1959 through 1977.

The years of serious damage (without regard to BLH abundance) are summarized in table 2. The relative severity of damage to beets is based on a combination of apparent yield reduction, percentage of acreage abandoned, published reports, and (for 1977) direct observation. The relative severity of damage to beans is based on published records and percentage of garden seed bean plants with 9.2 percent or more showing obvious CT symptoms. Infections of less than 9.2 percent were considered as nonserious.

Relative damage to beets is indicated somewhat arbitrarily as severe (*) to most severe (****) based on reduced yield, abandoned acres, and verbal statements comparing one year with another. For beans, * damage is 9.2 to 19 percent infected, ** damage is 20 to 39 percent infected, *** damage is 40 percent or more of plants infected or "serious," and **** is the verbal description of one year as "disastrous."

Beets

In the 23-year period 1919 through 1934, before the introduction of CT resistant U.S. 1, 9 years or about 40 percent could be considered as serious CT years to beets (table 3). During the 7-year "transition period" (1935-41), from the wide usage of U.S. 1 to the wide usage of the highly resistant U.S. 22, only 1941 (14.3 percent) was considered serious to beets. During the last 36 years (1942-77), only the years 1969 and 1977 (5.6 percent) can possibly be considered as serious. In 1969, damage was mostly in western Idaho (*37*), and in 1977 damage in south-central Idaho was spotty and most severe on the less resistant variety Mono-Hy D-2. Twelve percent of the Twin Falls Factory District acreage was planted to this variety in 1977.

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[3] Tables begin on p. 18.

Beans

Through 1934, records of damage to beans are incomplete. We found reference to 1924 (*7*), 1930 (*2*), and 1934 (*28*) as being very serious CT years for beans. Although only 13 percent of these years are recorded as serious, serious damage probably occurred in other years during this period since records were incomplete. Good records of percentages of bean plants infested were available from 1935 through 1958. From 1959 to 1977, records are again scanty. For the 17-year period 1942-58, when good records were still kept, the frequency was 23.5 percent for garden seed beans and zero for dry edible beans. During the last 19 years, 1959-77, although records are scanty, apparently no serious damage has occurred. Obviously, the seriousness of CT to beans has also declined drastically, but the decline occurred much later than for beets.

Over the years, the severity of damage has declined for both beets and beans. No area-wide serious decrease in beet yield due to CT has occurred since 1941, no ** infection of dry edible beans has occurred since 1935, and no ** infection of garden seed beans has occurred since 1947. This is in spite of the fact that overwintering BLH populations have often been 50 or more per 100 ft^2 (1944, 1948, 1950, 1954, 1957, 1962, 1966, and 1969), which was considered the action level for insecticidal control in desert areas (Idaho's Insect Reporter, May 5, 1975, Appendix II).

There is no apparent relationship between numbers of overwintering BLH populations or the percentage of those carrying the virus and damage to either beets or beans. Neither is there any relationship between years of damage to beets and beans. No serious damage was reported on beans for 8 years when damage occurred to beets. Likewise, no serious damage was reported on beets for 7 years when damage occurred to beans.

FACTORS AFFECTING SERIOUS CT DAMAGE

BLH Overwintering Populations and Percentage Carrying CT Virus

The relative importance of major areas in Idaho with respect to the abundance of the BLH was established early. On the basis of surveys made in 1926 and 1927, Haegele (*23*) presented a map of the breeding grounds. The breeding ground with high BLH populations extended in a band bordering the Snake River from Bingham County in the east to the western border of Idaho and continued a short distance into Oregon. He made sweep net collections (50 sweeps per collection) in stands of suspected host plants. The average number of BLH per collection and the number of collections from weed hosts, respectively, in the major beet growing areas were: western Oregon-eastern Idaho, 92.13 and 97; central plains, 58.04 and 173; and eastern Idaho, 8.60 and 144. In the mountainous areas of northern Idaho, where few or no beets are grown, the numbers were 19.78 and 138. These results were later substantiated by other workers.

Records of percentage of virus-infected beet plants (table 1) were available by area from 1930 through 1958. Clearly, infections in the Idaho Falls area in eastern Idaho were comparatively light but became progressively higher in areas further west. The average percentage of infected beets for the 7 years when all four areas were surveyed was: Idaho Falls, 9.08; Burley-Rupert, 37.81; Jerome-

Twin Falls, 50.87; and eastern Oregon-western Idaho, 55.77. For the 19-year period when only three areas were surveyed, the average was: Burley-Rupert, 18.00; Jerome-Twin Falls, 25.23; and eastern Oregon-western Idaho, 36.88. Thus, the incidence of CT in the eastern Oregon-western Idaho area is 1.5 to 2.0 times that in the Burley-Rupert area and about six times greater than that in the Idaho Falls area. The striking drop in infection in 1942 and continued low level through 1958 must be attributed primarily to the widespread usage of highly resistant varieties.

The same sort of data were obtained for beans in south-central Idaho for 1935 through 1959. The data were separated by categories of "garden seed beans" and "Great Northerns" (a dry edible bean). The garden seed bean category sustained two to seven times more infection than dry beans. There was no sudden or gradual dropoff in infection rate; the 5 years of highest infection were 1935, 1937, 1941, 1947, and 1957. Although comparable data beyond 1959 are not available, the last year of significant incidence of CT in beans was 1957. From discussions with seed company representatives, this is probably due in large part to their avoiding planting beans of susceptible varieties in localities with a history of CT damage, mainly in the western part of the cultivated area in south-central Idaho or near desert weed host areas.

Correlations between sets of data presented in table 1 were run for the 17-year period 1942-58. These were the years beginning with the widespread use of beet varieties highly resistant to CT and, thus, are fairly comparable in this regard. None of the sets of data or combinations of data correlated significantly with any other set as shown in table 4. The only correlations that came close to being significant at the 5-percent level were those between the percentage of virus-infected beet plants in the Twin Falls-Jerome area and the percentage of virus-infected bean plants. From this, it appears that neither leafhopper populations or percentage of viruliferous hoppers, or a combination of these had value in predicting infection in beets or beans, beet yield, or percentage of beet acres abandoned.

Development of CT Resistance

Sugarbeets

An excellent summary of the development of beets resistant to CT was presented by Bennett (*5*). The years 1935-41 should be considered as a transition period in the use of resistant varieties. As described by Murphy (*38*), the first variety resistant to CT, U.S. 1, came into general use in 1935 and was rapidly succeeded by the successively more resistant varieties U.S. 34, A-600, U.S. 12, and U.S. 22. In 1942, the entire acreage was planted with U.S. 22. The yield of some of these grown under severe CT exposure at Buhl, Idaho, in 1941 illustrates the progress made.

Variety	*Tons/acre*
Old type	0[1]
U.S. 1	6.31
U.S. 12	11.25
U.S. 22/1	14.32
U.S. 22/2	16.61

[1]0.73 in Bennett (5).

Bennett (5) stated, "with continued improvement in resistance, curly top has ceased to be a major limiting factor in sugarbeet production." This has been true through the years as long as varieties with maximum CT resistance have been used. Beginning in 1973, however, varieties other than those of The Amalgamated Sugar Co. (TASCO) were planted in the Twin Falls Factory District, in percentages of total acreage, as follows:

Year	TASCO (AH-3 and 10)	Holly HH-22	Great Western Mono-Hy D-2
1973	98	2	0
1974	80	20	0
1975	89	11	0
1976	83	16	1
1977	77	11	12

The relative performance of these varieties under various CT conditions is presented in table 5. AH-10 and HH-22 were approximately equal in CT ratings and yield except in the test where viruliferous BLH were caged on plants. In this case, AH-10 yield was reduced only slightly, HH-22 yield was reduced markedly, and yield of D-2 was reduced even further. In 1977, under a severe natural CT infection, Mono-Hy D-2 yielded only half of that obtained with AH-10, but yields of both were drastically reduced. The indication is that planting less resistant varieties in areas prone to CT will tend to increase both the incidence and severity of CT unless the less resistant varieties can be protected by chemical treatment or some other means.

Beans

Bennett (5) also summarized the development of CT resistance in beans. Highly resistant varieties of dry edible beans were found and developed in the 1930's (*24*, *40*, *41*, *46*), but most snap bean varieties continue to be susceptible. The CT status of garden or snap seed beans is complicated by the large number of types and varieties grown in south-central Idaho.

University of Idaho research personnel have been very active in the development of resistance to CT in beans. Murphy (*40*, *41*) described dry bean varieties highly resistant to CT. Schultz and Dean (*46*) described the mode of inheritance of CT in beans. Hungerford (*29*) listed 8 of 11 dry bean varieties as resistant to CT. Dean and LaFerriere (*12*) listed 8 of 17 dry bean varieties as resistant to CT. Kolar and LeBaron (*32*) listed 53 varieties of dry beans grown, or which might be considered for growing, in southern Idaho. Of these, 24 were classed as resistant to CT, one as moderately resistant, and one as tolerant. Twenty-two were classed as susceptible, four as questionable, and one had no designation. Thus, approximately one-half of the varieties listed in 1976 were resistant to CT. In 1954, Dean and Hungerford (*11*) described the first development of two snap beans resistant to CT. Dean and LaFerriere (*12*) listed 2 of 30 garden or snap beans as resistant to CT. Additional development of resistant snap beans was reported by Dean and LeBaron (*13*), Dean (*9*), Dean (*10*), and Dean (1978, personal communication; release of variety Canyon to industry in 1973).

Commercial bean breeders have also been active in the development of resistance to CT, but records are not available.

Time of Spring Movement of Beet Leafhoppers

The size of BLH populations in the spring and the potential for crop damage is dependent upon a complex of weather factors directly influencing BLH development throughout the year, and, indirectly, through their influence on the succession, abundance, location, and condition of host plants (*8*, *20*, *25*, *50*, and "Statements on Beet Leafhopper Conditions," Appendix II).

Larger beets are less subject to CT damage (*5*). Wallace and Murphy (*50*) stated, "The size of beets, or stage of development at time of infestation with leafhoppers, will continue to be an important factor in the curly top problem in southern Idaho...Early plantings will usually result in more or less negligible injury...while late plantings may be damaged appreciably."

Thus, the timing of BLH movement into cultivated fields in relation to plant growth appears to be the most important factor, aside from plant resistance, in determining CT damage to beets. The earlier the movement or the smaller the beets at time of movement, the greater the damage. This was investigated in some detail for 1927-36 by Harries and Douglass (*25*), for 1930-37 by Fox et al. (*20*), and for 1935-44 by Douglass et al. (*18*). For 1945-59, actual dates of initial BLH movement were reported in the annual statements of "Beet Leafhopper Conditions for Southern Idaho" (Appendix II). These records of initial BLH movement into beet fields are summarized in table 6 and compared with our assessment of years of serious damage. Early initial movement was highly correlated with above normal temperature during February, March, April, and May (*25*).

Before 1935, damage occurred when initial movement occurred on or before May 24, and most severe damage occurred in 1934 when movement started very early on April 27. During the transition period, when resistant varieties were being introduced, only the year of earliest movement (1941) suffered damage although in two other years movement started before May 24. During 1942-59, initial movement began before May 24 six times, but no serious damage occurred.

In the April 20, 1961, issue of "Beet Leafhopper Conditions for Southern Idaho" was the statement, "During the past 25 years, the average initial spring movements have started on May 25 and reached their peaks on June 23. Most of the leafhoppers enter the fields within a week or 10 days before the peak."

That spring rainfall is also an important factor in spring BLH migration is evidenced by a statement repeated in issues of the "Beet Leafhopper Conditions for Southern Idaho" for 1949-52 (Appendix II): "An early movement of the leafhopper from the spring breeding areas may be expected during an early spring with normal rainfall, whereas during a late spring and above normal rainfall, the movement of the leafhoppers is retarded." That spring rainfall has an effect on host plants and, in turn, on BLH migration was implied in the June 5, 1959, issue: "Many of the spring hosts, as well as Russian thistle, are in fair condition from recent rains and will attract and hold some of the spring mi-

grants. Consequently, the number that will move into the cultivated areas... should be comparatively light."

The pattern is not nearly so clear with respect to CT damage to beans. Rather severe damage occurred to beans when initial leafhopper movement began as late as June 5 (1935) and as early as April 27 (1934). Beans are planted much later than beets and would, therefore, be more susceptible to later influxes of leafhoppers. Larson and Hallock (*34*) presented CT infestation data for successive dry bean plantings in the Twin Falls and Filer areas at six locations for 1936-39. In all but one location, the incidence of CT increased from plantings made May 8-11 to plantings made June 5-7. In plantings made after June 5-7, the incidence of CT increased in four fields and decreased in two fields (fig. 1).

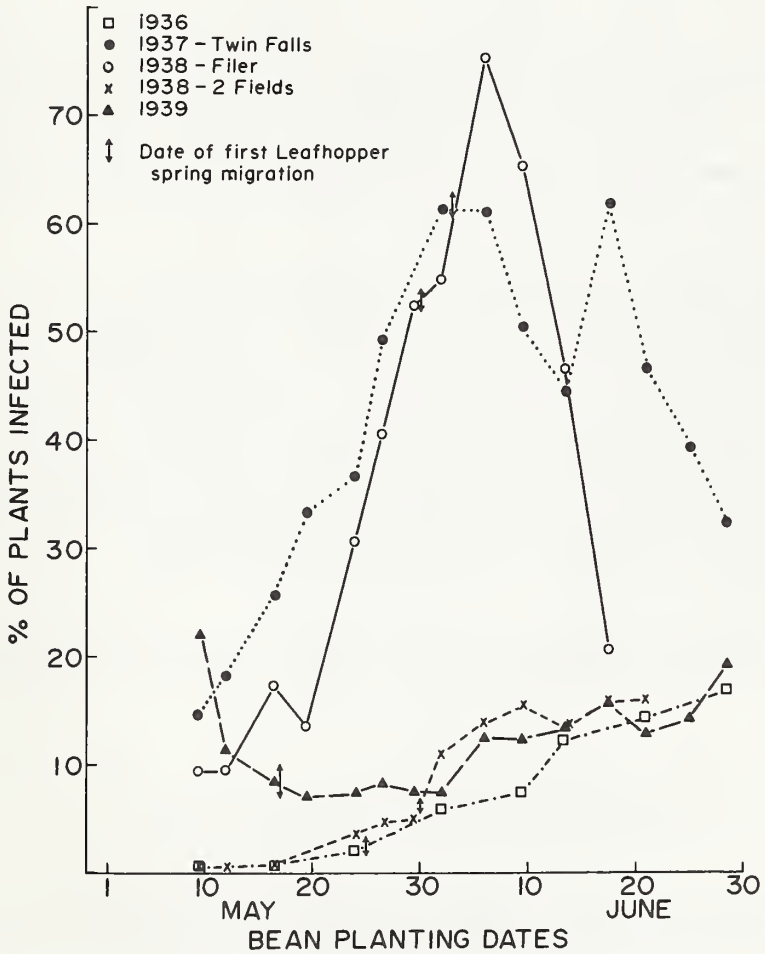

Figure 1.--Incidence of curly top in dry beans in successive plantings, 1937-39, in south-central Idaho (from Larson and Hallock (*34*)).

Insecticidal Control of Beet Leafhopper in Desert Breeding Areas

From 1949 through 1969, 206,000 acres of weedy host plant desert area were sprayed for direct control of BLH (table 7). Areas treated were those found

during spring surveys that supported high populations of leafhoppers. Spraying was done in early spring before BLH migration to cultivated areas could occur. The early control efforts from 1949 through 1953 were directed primarily toward reducing CT in snap beans (*19*). The authors reported the program to be highly successful, even though in 1949 and 1950 "the acreage to be sprayed was limited by the equipment available and by the time during which operations could be conducted effectively, and in 1953 it was also limited by available funds." As a result of spraying operations, the authors reported that the incidence of CT in beans was reduced below the expected by zero in 1949, 42 percent in 1950, 57 percent in 1951, and 83 percent in 1952. We find this report unconvincing. Evaluation of the effectiveness of spraying desert areas since 1956 has not been attempted. Any real effect of reducing CT in beans by reducing BLH populations in desert areas would also reduce CT in beets.

The importance of BLH breeding areas within the cultivated area was emphasized in several of the issues of the "Beet Leafhopper (Whitefly) Conditions in Southern Idaho" (Appendix II). For example, in the issue dated May 9, 1956, is the following: "Within the cultivated areas...there are a great many small patches of wild mustards, principally flixweed, pepperweed, and tumblemustard, growing on idle and waste lands. These areas occur along roadsides, canals, ditchbanks, pastures, and earth-covered potato cellars, and in similar places. These small areas may range in size from a few square feet to an acre or more and, frequently, are the source of leafhoppers that cause the greatest amount of damage to beans and other susceptible garden crops grown near these patches." Again, in the April 27, 1959, issue: "In unirrigated waste patches such as corrals, potato pits, high spots, and lava outcroppings adjacent to and within cultivated areas, host plants are in good condition for producing a large spring generation. These areas offer the greatest threat to the cultivated crops." In several issues, it was advised that in these areas, the BLH should be controlled either directly with insecticides or indirectly by eliminating weed hosts by the use of herbicides or reseeding to grasses.

Increased General Use of Insecticides and Herbicides

Although no readily available data on the use of insecticides and herbicides could be found for cultivated areas of southern Idaho, pesticide use in the United States has increased dramatically since 1945 (*26*, p.22). From 1966 to 1971, the percentage of U.S. sugarbeet acreage treated with herbicides increased from 33 to 75; that treated with insecticides increased from 12 to 30 (*1*). For the Mountain States region, which includes Idaho, the percentage of sugarbeet acreage treated with herbicides in 1971 was 65, and that treated with insecticides was 29.

Research has shown that a number of insecticides have been found effective in killing BLH and reducing CT symptoms in beet and bean fields: pyrethrum (*45*); DDT (*14*, *16*, *17*, *39*); malathion (*15*); phorate (*15*, *27*, *35*, *36*, *42*); disulfoton (*27*, *35*); dimethoate (*42*); aldicarb (*35*, *36*, *44*); and carbofuran (*35*, *36*).

None of these have proven of practical use as foliage applications for direct BLH control or suppression in beet or bean fields; however, soil-applied

systemic insecticides have sometimes provided a reduction in CT symptoms and increased yields of sugarbeets. In Idaho, phorate and aldicarb have been used rather extensively for sugarbeet root maggot, *Tetanops myopaeformis* (Röder), control. Disulfoton and carbofuran are also registered for this use. In five insecticide tests in Idaho in 1974-77 for control of sugarbeet root maggot where moderate CT symptoms appeared, we observed an average of 63.7 percent reduction in CT symptoms following aldicarb applications (2 lb active ingredient per acre) (unpublished). These usages on sugarbeets, as well as on other crops, have undoubtedly had a suppressive effect on BLH populations and damage.

Rangeland Improvement

Overall rangeland improvement in Idaho began in the 1940's and has been treated in detail by Godfrey (*22*) and summarized by Sharp and Sanders (*47*). Through 1970, the U.S. Bureau of Land Management (BLM) had seeded 992,000 acres, of which only 2.4 percent had been accomplished prior to 1950. In addition, 549,000 acres had been seeded by ranchers on private and State-leased land. Thus, approximately 1.6 million acres have been planted to adapted species, principally crested and desert wheat grasses (*Agropyron cristatum* and *A. desertorum*) (*47*).

A part of this overall program was directed toward replacement of desert weed host areas with grasses to reduce CT. The "beet leafhopper program" was funded by the U.S. Congress specifically for this purpose, and additional private funds were contributed by rangeland users. The program, from its initiation in 1958 through 1962, was summarized by Gibson and Fallini (*21*). During that period, 116,000 acres were seeded by the BLM in cooperation with other interested private, State, and Federal agencies. Under this program, an additional 95,000 acres were seeded by 1972 for a total of 211,000 acres (correspondence W. E. Peay to E. F. Knipling, July 12, 1972). The program was only partially successful in that many seedings did not become established and remained as weed host areas. For various reasons, some important weed host areas were not seeded. In addition, important new weed host areas developed due to range fires and clearance of land for irrigation, which was not completed. No estimate of the effect of this program in reducing BLH populations has been published.

Increase in Size of Cultivated Area

Irrigated land in Idaho is confined largely to the southern area, and sugarbeets are grown exclusively on irrigated land. Any increase in irrigated (or cultivated) land would decrease the amount of potential weed host area available and necessary for overwintering BLH. Exact data are not readily available. Figure 2 shows the acreages in Idaho in total cropland and irrigated land (*48*, *49*) planted to beets (*30*) and the acreages planted to beans (*48*,*49*) from 1924 through 1977, and also indicates the years of serious CT damage to beets and beans. Acres irrigated and in total cropland show a steady increase during this period. Beet acreages also trend upward but with considerable year-to-year variation. Bean acreage since 1929 has been relatively constant. These trends would tend to (1) decrease the leafhopper population, (2) dilute the numbers of

migrating leafhoppers in the spring over a larger cultivated area, and (3) perhaps limit severe infestations to the periphery of the cultivated areas.

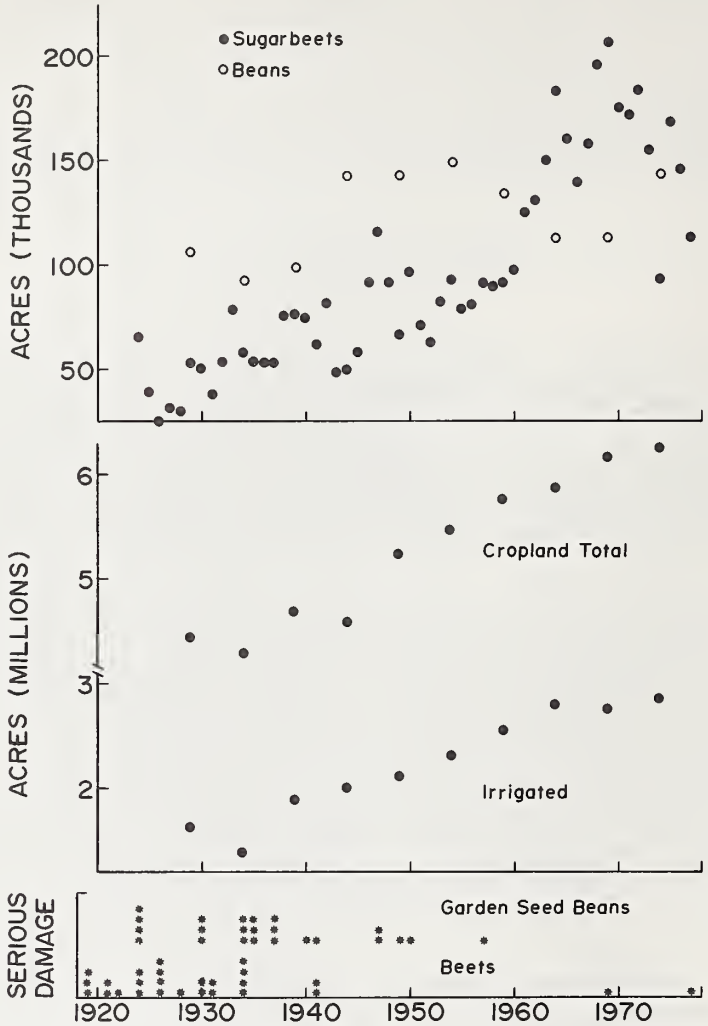

Figure 2.--Acres of land in Idaho in various use categories and years of serious curly top damage to beets and beans.

SUMMARY

Many factors influence CT damage to beets and beans: plant resistance, reduction of breeding areas due to grass seeding and land broken out for cultivation, direct insecticidal control in desert areas, general increased use of insecticides and herbicides in cultivated areas, and increased size of area under cultivation. It is difficult to assess the individual importance of these various factors. The reduction in frequency and intensity of CT damage to beets and beans since 1942 is very probably due to a combination of factors; however, plant resistance to CT in beets was obviously the dominant force in reducing beet losses since damage was immediately and drastically reduced by the widespread use of highly resistant varieties. The reduction in damage to beans was less dramatic than in beets and occurred later. This is probably due to the

later development and less extensive use of resistant bean varieties.

While much effort and good work went into the BLH breeding ground surveys and viruliferous testing through the years, this was of little practical value for advance forecasting of bad CT years. Correlations are very poor between years of severe CT damage and either number or viruliferousness of leafhoppers in the desert breeding grounds. Weather conditions as they affected desert host plant growth were the main factors that triggered BLH movement onto cropland.

The potential for extensive sugarbeet losses due to CT is still present. Research demonstrates that unless a highly CT resistant variety of beet is planted, the crop should be protected with a systemic insecticide. This is especially important in the area from Twin Falls County westward.

With the increasing development and use of bean varieties resistant to CT, there appears to be minimal danger from heavy CT losses, providing the planting of susceptible varieties near weed host areas is avoided.

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APPENDIX I

Beet Yield

Yields in tons per acre for the Twin Falls Factory District were obtained from The Amalgamated Sugar Co. (TASCO) records. These differ slightly from average yields given by Murphy (*38*) for 1916-45. Yield data for 1912-15 are only for the TASCO Burley-Rupert area, which is adjacent to Twin Falls. The geographical area covered by the Twin Falls Factory District currently includes Twin Falls, Jerome, and Gooding Counties but has varied somewhat during the years reported. For example, in 1966-68 it included the area as far west as Mountain Home. Acreages harvested have varied from 5,321 in 1912 to a low of 283 in 1928 and a high of 35,856 in 1969.

Abandoned Acres

The percentage of acres abandoned was based on the records presented by Murphy (*38*) for 1912-45. For 1946-77, this percentage was based on records furnished by TASCO.

Overwintering BLH Populations in the Spring

For 1942-56, the values given are simple averages of values given in unpublished USDA annual reports for three areas of weed hosts (eastern Oregon-western Idaho desert, cultivated areas of eastern Oregon-western Idaho, and the cultivated area of south-central Idaho). Values for the "combined breeding areas" were given for 1957-72 in the Idaho's Insect Reporter, May 3, 1972. For 1973-77, values were obtained from separate issues of the Idaho's Insect Reporter. Every year, populations varied greatly from one area to another and for localities within areas. Detailed surveys were conducted by USDA research personnel through 1959. In 1960, responsibility for surveys was transferred to survey personnel of what is now the Animal and Plant Health Inspection Service, and the surveys became progressively less intensive (Appendix II).

Percentage of Overwintering BLH Carrying Curly Top Virus

These percentages were determined by USDA research personnel at Twin Falls. Values for 1938-50 were summarized in an unpublished annual research station report for 1950. Through 1956, values were taken from unpublished annual research station reports. For 1957-77, values were taken from annual issues of either the Idaho's Insect Reporter or mimeographed releases on beet leafhopper conditions.

Percentage of Beets and Beans Obviously Infected with CT

These data were obtained from detailed unpublished annual reports of research conducted by USDA personnel at Twin Falls. These surveys were conducted annually from 1935 to 1958. Various segments of the above have been published in detail (*24*).

APPENDIX II

Mimeographed statements on beet leafhopper surveys and conditions in Idaho were prepared and issued annually for timely release to the public beginning in 1927.

From 1927 through 1935, these were special releases for selected counties in south-central Idaho.

From 1936 through 1976, these were special releases exclusively on "Beet leafhopper conditions in southern Idaho for 19__," or second or third "Statement on beet leafhopper conditions in southern Idaho for 19__."

Beginning in 1977, other insects on other crops were included in the issues, and the designation "Beet leafhopper conditions..." was discontinued.

1927 (Jan. 28), 1928 (Feb. 29), 1929 (Feb. 18), 1930 (Feb. 24): Walter Carter, USDA, Bureau of Entomology.

1930 (June 13), 1931 (Feb. 28), 1932 (Feb. 26): P. N. Annand, USDA, Bureau of Entomology.

1933 (Feb. 24), 1934 (Feb. 23): J. C. Chamberlin, USDA, Bureau of Entomology.

1935 (Mar. 7), 1936 (May), 1937 (May 4, 24), 1938 (Apr. 30, May 18, June 30), 1939 (May 1, 23), 1940 (May 20, June 10), 1941 (May 2, 27), 1942 (May 2, June 17), 1943 (Mar. 30, May 8, June 29), 1944 (Apr. 11, May 24), 1945 (May 1, 14), 1946 (Apr. 4, May 21), 1947 (Apr. 1, May 21), 1948 (Apr. 24, May 25), 1949 (Mar. 29, May 17), 1950 (Apr. 13, June 1), 1951 (Apr. 25, May 17), 1952 (Apr. 30, May 23), 1953 (May 5, 20): J. R. Douglass, USDA, Bureau of Entomology and Plant Quarantine.

1954 (May 4, 25): J. R. Douglass, USDA, Entomology Research Branch and R. W. Portman, University of Idaho, Extension Service.

1955 (May 23, June 14), 1956 (May 9, June 4): J. R. Douglass, USDA, Entomology Research Branch.

1957 (May 11, June 5), 1958 (Apr. 25, June 13), 1959 (Apr. 27, June 5): Twin Falls Field Station Staff, USDA, Entomology Research Division.

1960 (Apr. 21, May 26), 1961 (Apr. 20, May 29): R. W. Portman, University of Idaho, Extension Service (Surveys conducted by Plant Pest Control Division, USDA, Research data from Entomology Research Division, USDA).

1962 (Apr. 18, May 15), 1963 (Apr. 26, May--), 1964 (Apr. 24): R. W. Portman, University of Idaho, Extension Service, and Keith Evans, USDA, ARS, Plant Pest Control Division.

Beginning in May 1964, and except for the Apr. 19, 1965, issue, statements were separate issues of Idaho's Insect Reporter.

1964 (May): R. W. Portman, University of Idaho, Extension Service, and Keith Evans, USDA, ARS, Plant Pest Control Division.

1965 (Apr. 19): R. W. Portman, University of Idaho, Extension Service, and Keith Evans, USDA, ARS, Plant Pest Control Division.

1965 (May), 1966 (Apr. 12, May 18), 1967 (Apr. 26, May 18), 1968 (Apr. 18): R. W. Portman, University of Idaho, Extension Service, and Keith Evans, USDA, ARS, Plant Pest Control Division.

1968 (May 19): L. E. O'Keeffe, University of Idaho, Extension Service,and Keith Evans, USDA, ARS, Plant Pest Control Division.

1969 (Apr. 14, May 19), 1970 (Apr. 17, May 25), 1971 (Apr. 22, June 7), 1972 (May 3): R. W. Portman, University of Idaho, Extension Service, and Keith Evans, USDA, ARS, Plant Pest Control Division (1972-APHIS).

1973 (Apr. 24): R. W. Portman, University of Idaho, Extension Service, and R. J. Pollard, USDA, APHIS, Plant Protection and Quarantine.

1974 (Apr. 29), 1975 (May 9), 1976 (May 5): H. W. Homan, University of Idaho, Extension Service, and R. J. Pollard, USDA, APHIS, Plant Protection and Quarantine.

1977 (Apr. 27): H. W. Homan, University of Idaho, Extension Service.

APPENDIX III

Table 1.--*Sugarbeet yields, abandoned acreages in the Twin Falls Factory District (T.F.F.D.) of southern Idaho, overwintering (O.W.) beet leafhopper populations, percentage of those carrying curly top virus, and magnitude of infected beets and beans, 1912-77*[1]

Year	Beet yield for T.F.F.D. (tons/acre)	Percent beet acreage abandoned	O.W. hoppers in spring combined breeding areas		Severity of infection[2] or percent virus-infected beets in July-Sept.			Severity of infection[2] or average percent virus-infected beans: July and Aug., south-central Idaho	
			No./100 ft^2	Percent viruliferous	E. Oreg., W. Idaho	Jerome-Twin Falls	Burley-Rupert	Idaho Falls	Garden seed	Dry edible
1912	7.21	13.7								
1913	8.40	13.2								
1914	10.43	4.4								
1915	10.66	3.3								
1916	12.13	17.9								
1917	10.91	10.9								
1918	11.88	12.2								
1919	7.65	32.5				*5*				
1920	11.53	14.2								
1921	7.97	15.6				*5*				
1922	13.52	14.6								
1923	14.19	1.0								
1924	5.49	51.0				*5*				*6*
1925	14.26	([3])								
1926	5.71	70.3				*6*				
1927	15.21	8.2				*2*				
1928	8.69	7.0				*3*				
1929	12.16	15.2				*0*				
1930	8.53	21.1				100	100		5	5
1931	7.44	([3])				100	100			
1932	16.43	.1		8.9		70	43			
1933	14.24	([3])				36	12			
1934	4.89	87.1				100	100		5	5
1935	15.25	1.1		18.0		87	73		5	18.8
1936	14.89	6.9				64+	48+		3-5	
1937	11.07	3.8				53	9		44.5	16.8
1938	15.81	4.4		10.0	98.1	98.6	47.0	1.9	2.2	1.2
1939	16.16	4.7		12.4	74.4	41.8	26.5	3.9	.6	.2
1940	17.92	4.4		10.4	99.2	88.0	77.0	26.2	9.2	2.5
1941	13.25	2.7		7.6	98.9	99.0	97.5	27.1	12.9	10.5
1942	19.19	2.8	17	31.7	67.8	14.4	6.1		1.3	.2
1943	20.61	20.0	10	1.2	51.7	19.8	3.4		.3	.04
1944	18.20	15.6	61	0.4	46.1	13.9	14.2		1.0	.2
1945	17.46	9.9	30	5.5	13.2	6.8	1.5		7.7	2.7
1946	19.27	12.8	9	5.2	15.5	5.6			1.9	.3
1947	17.42	16.0	25	14.2	9.6	18.3	10.5		20.2	6.9
1948	16.94	20.6	50	10.3	15.2	6.0			4.7	.8
1949	17.62	11.2	17	8.3	13.1	14.9	18.8		12.2	4.7
1950	19.26	10.6	87	15.8	14.9	7.6	5.0		9.6	3.6
1951	20.68	8.7	49	21.3	31.4	5.3	1.5		3.9	1.4
1952	20.68	9.4	25	17.6	25.7	7.2	6.2		.8	.2
1953	22.14	5.9	72	6.0	12.4	5.6	2.3		1.9	.4
1954	20.14	5.4	97	13.8	21.7	7.5	9.3		2.1	.5
1955	19.59	3.6	18	7.6	2.8	1.9	1.1		.3	0
1956	23.37	6.2	26	1.7	7.1	2.0	1.1	.6	2.6	.7
1957	21.91	3.6	65	4.0	10.4	9.6	3.0	2.3	18.1	6.3
1958	23.81	2.7	16(23)	13.6	2.3	17.1	10.5	1.6	6.6	.5
1959	23.92	6.3	17	10.1					.5	
1960	20.70	1.8	19	15.5	*4*	*2*			*0*	*0*
1961	22.69	4.4	44	0-31	*0*	*0*	*0*		*0*	*0*
1962	20.70	2.3	72	5-22						
1963	24.67	3.0	16	4.0						
1964	17.70	4.8	22	7.2	*0*	*0*	*0*		*0*	*0*
1965	19.63	1.1	18	<1.0	*1*	*1*	*1*		*0*	*0*
1966	20.30	5.7	90	4.0						
1967	21.22	10.2	22	5.0	*1*	*1*	*1*		*0*	*0*
1968	20.40	7.6	42	5-22						
1969	18.20	8.0	60	28(5-81)	5	35.4			*2*	*2*
1970	19.77	3.8	28	4-22	*1*	*1*	*1*			
1971	20.30	3.7	34	<4.0(0-24)	*1*	*1*	*1*			
1972	22.48	4.0	7		*1*	*1*	*1*			
1973	20.30	4.5	31	10.3						
1974	19.50	3.0	10							
1975	18.70	12.6	39							
1976	20.80	3.8	10							
1977	17.30	17.8	17			*3*				

[1]Sources of data are discussed in the text.

[2]Italic numbers refer to verbal descriptions in reports: *0*, none, negligible, one of lowest on record; *1*, very low, very light; *2*, light, some spotty; *3*, some severe locally; *4*, general; *5*, severe, serious, bad; and *6*, extreme, disastrous.

[3]Data missing.

Table 2.--*Years of serious curly top damage to sugarbeets and beans in southern Idaho*

Year	Lange[1] 1971	Present authors[2]	
		Beets	Beans
1919	✓	***	
1921	✓	**	
1922	✓	*	
1924	✓	***	****
1926	✓	****	
1928		*	
1930	✓	**	***
1931	✓	**	
1934	✓	****	***
1935	✓		***
1937	✓		***
1940	✓		*
1941	✓	**	**
1947	✓		**
1949			*
1950	✓		
1957			**
1969	✓	[3]*	
1977		[4]*	
Total years		12	10

[1]Lange included years when leafhoppers were abundant.
[2]Most severe (****)to relatively slight (*) damage.
[3]Western Idaho.
[4]South-central Idaho.

Table 3.--*Number of years in which severe damage occurred and relative severity[1] of damage by time periods, 1912-77*

Period	Beets					Beans				
	****	***	**	*	Percentage of period	****	***	**	*	Percentage of period
1912-34 (23 yr)	2	2	3	2	39.1	1	2	0	0	13.0
1935-41 (7 yr)	0	0	1	0	14.3	0	2	1	1	57.1
1942-53 (12 yr)	0	0	0	0	0	0	0	1	1	16.7
1954-65 (12 yr)	0	0	0	0	0	0	0	1	0	8.3
1966-77 (12 yr)	0	0	0	2	16.7	0	0	0	0	0

[1]Most severe (****) to relatively slight (*) damage.

Table 4.--*Correlations between selected values in table 1 for 1942-58*

Item	Number of viruliferous leafhoppers in 100 ft^2 combined breeding areas	Percentage of infected beets Twin Falls-Jerome area
Yield Twin Falls Factory District (tons/acre)	-0.03017	+0.05056
Abandoned acres Twin Falls Factory District (percent)	- .17396	+ .21529
Virus-infected beets (average 3 areas) (percent)	- .05263	
Virus-infected garden seed beans, south-central Idaho (percent)	+ .03826	+ .33129
Virus-infected dry beans south-central Idaho (percent)	+ .06297	+ .45966

Table 5.--*Performance of principal sugarbeet varieties planted in the Twin Falls District area in 1973-77 under various curly top conditions*

	Curly top ratings[1]		Yield (tons per acre)			
	Logan, Utah, 5-yr average 1973-77	Nyssa, Oreg., 1977, 8 replications	No CT Ontario, Oreg., 1977	Mild CT Grandview, Idaho, 1973	Cage test with viruliferous hoppers, 1976	Severe CT split field (Buhl, 1977)
AH-10	3.74	3.7	32.7	32.9	28.0	12.2
HH-22	3.80	3.7	32.0	33.2	21.8	
Mono-Hy D-2	5.24	4.8	34.9	29.5	18.8	6.0

[1]0 = none, 9 = severe.

Table 6.--*Interrelationships among date of beet leafhopper initial movement into beetfields, seriousness of curly top damage to beets and beans, and the development of beet varieties resistant to curly top, 1927-59*

Date of initial movement	Sugarbeets			Garden seed beans
	Before U.S. 1 (1927-34)	Transition period (1935-41)	After U.S. 22 (1942-59)	
Apr. 27	[1](34)[2]****			(34) ***
May 7			(47)	(47) **
12		(41) **		(40) *
14	(28) *			
15			(44)(53)	
17		(39)	(49)	(49) *
20		(40)	(46)	(40) *
21			(54)	
24	(30) **			(30) ***
24	(31) **			
25		(36)	(48)(59)	
26			(43)(50)	(50) *
29			(56)(57)	(57) *
30		(38)		
31			(51)	
June 1			(42)(45)	
2		(37)	(52)	(37) ***
5		(35)		(35) ***
6	(33)			
8			(55)	
9	(29)			
13	(27)			
13	(32)			

[1]Specific years are in parentheses.
[2]Most severe (****) to relatively slight (*) damage.

Table 7.--*Acres sprayed and material used in control projects*[1] *for reduction of beet leafhopper in desert weed host areas in southern Idaho, 1949-69*

Year	Acres sprayed	Material used
1949	2,600	Pyrethrum.
1950	15,000	DDT.
1951	6,300	Do.
1952	0	
1953	11,350	Do.
1954	0	
1955	0	
1956	12,912	Do.
1957	8,493	Do.
1958	3,330	Do.
1959	2,891	Do.
1960	0	
1961	14,844	Do.
1962	13,965	Do.
1963	0	
1964	11,344	Malathion.
1965	0	
1966	39,710	Do.
1967	5,952	Do.
1968	14,288	Do.
1969	43,020	Do.

[1]Sources of information: Douglass et al. (*19*) for 1949-53; personal communication from Roger Pollard, Animal and Health Inspection Service, U.S. Department of Agriculture, Twin Falls, Idaho, for 1954-69.

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